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Phenotypic Characterization of Various Goats Gene Pool (*Capra hircus*) in Oriental Mindoro

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Abstract

This study aims to phenotypically characterize Philippine Native, Upgraded, Anglo Nubian, Boer, and Saanen goats. A total of 118 goats from 14 goat semi-intensive farms were used. Qualitative data were analysed using descriptive analysis while quantitative traits using Scheffe's test. Results showed variations in the phenotypic characteristics of a goat gene pool. Saanen had longer body length significantly, and higher wither height. Saanen and Boer goats appeared to have higher heart girth. Saanen and Anglo Nubian has significantly higher testicle circumference and tail length. Boer, Anglo Nubian, Upgraded, and Philippine Native goats have predominantly mixed color while Saanen goats have solid coat color. The nose bridge width and ear length (EL) of Anglo Nubian goats were significantly denser and longer. The EL of bucks were significantly longer than the EL of does. More than half of the Anglo Nubian, Upgraded, and Philippine Native, Boer and Saanen buck have horn while the majority of the does are dehorned. Regardless of sex, majority of the Boer and Upgraded goats have droopy ears while more than half of the Anglo Nubian goats have long droopy ears. All Saanen and Philippine Native goats have erect ears. Findings can serve as a basis for the establishment of further goat characterization, conservation, improvement and specific trait selection strategies for future breeding programs.

Keywords: Philippine Native goat, Anglo Nubian, Saanen, Upgraded goat, Boer

1 Introduction

Identification, characterization and documentation of goat breeds are important for any type of development or improvement of breed. Without such documentation, it would be difficult to know the animals and their potential Kassahun (8). Appropriate design of breeding program is impossible for breeds/types that have not been adequately characterized either phenotypically or genetically Mwacharo (10). Phenotypic characterizations are important in breed identification and classification.

Moreover, no morphological characterization of local genetic plays a very vital role in classification (i,e. size and shape) of animals which can be of great economic indicator (11). Counterpart is improved utilization and conservation of goat genetic resources. The economic values for different quantitative characteristics, implies that genetic and phenotypic improvement of these traits would have a positive effect on the profitability and economic viability of production. The results from the data gathered may serve as basis in comparing the breeding efficiency of local goat breeds in Oriental Mindoro to other goat in neighboring provinces research guide in goat breeding and genetic attributes.

Mindoro is the top goat producing area in the region, however, data are insufficient in the phenotypic characterization of goat breeds in the province. Phenotypic traits are important economically (14); which pose a bigger challenge for scientific researches on the identification of the local breed.

Phenotypic characterization of different goat breeds in Oriental Mindoro is considered one of the primary requirements in the establishment of selection and breeding program. This study aimed to phenotypically distinguish and compare the difference of various goat breeds available in Oriental Mindoro. Regardless of production systems, goats were described according to coat color and markings, face profile and body measurements such as body lengths, wither height, heart girth, testicle circumference and tail length. Although weight is an important factor in selection, knowledge of the phenotype essential to growth trait (i.e. BL, WH, HG) is utmost importance in selection hence body measurement was part of the data gathered.

In addition, identification and characterization of different economic traits in goats serve as springboard to develop

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breed that are locally adaptable which could provide high economic profit especially to small hold farmers. There are limited studies on the phenotypic characteristics, both qualitative and quantitative attributes of Philippine goat breed (1,5). There is limited publication on the phenotypic characterization of goat trait that are reared in Oriental Mindoro hence the study was conducted.

2 Materials and Methods

This study was conducted from May, 2018 to September, 2018 at the identified selected focal farms based on the records reported by PSA (14), Goat Farms Directory of the Livestock Research Division, Philippine Council for Aquaculture and Agriculture Research and Development (LRD-PCAARRD), and the Goat Population Inventory of the Federation of Goat and Sheep Performance Association in the Philippines, Inc. (FGASPAPI) and Municipal Agriculturist Officer (MAO) in Oriental Mindoro.

The different Municipalities in Oriental Mindoro has been considered in this study. The top goat producing municipalities with the highest goat density was used as focal farms (12,14).

A total of 14 goat farms were visited in Oriental Mindoro, which composed of seven municipalities for District I and seven municipalities for District II. The specific municipalities (Table 2) has identified based on Goat Farms Directory of the Livestock Research Division, Philippine Council for Aquaculture and Agriculture Research and Development (LRD-PCAARRD), Goat Population Inventory of the Federation of Goat and Sheep Performance Association in the Philippines, Inc. (FGASPAPI) and the National Goat Farm Production Performance in the Philippines (NGFPP) Directory, and data from Municipal Agriculture Officer (MAO) in Oriental Mindoro.

Table 1: Different municipalities of Oriental Mindoro as focal farm during the conduct of the study

PROVINCE	DISTRICT	MUNICIPALITY
Oriental Mindoro	District I	Baco, San Teodoro, Naujan, Puerto Galera, Victoria, Pola, Soccoro,
Oriental Mindoro	District II	Bansud, Pinamalayan, Gloria, Bongabong, Roxas, Mansalay, Bulalacao.

2.1 Phenotypic Characterization

The phenotypic traits used in the study were based on phenotypic characterization of Animal Genetic Resources of FAO in goats (6). These include sex (female and male), estimated age (year by age) or dentition class (kid, grower, adult), coat color, facial (nose bridge width), horn type, ear type, ear length, body lengths, wither height and heart girth and other body measurements such as testicle circumference and tail length. Visual observation was made and morphological features were recorded based on breed morphological characteristics described list of FAO for phenotypic characterization of goat (6).

Different body measurements were taken when animals are in pens or barns and not when the animals are nervous to prevent stress in the part of the animals that may affect their performance (6). Data were obtained early in the morning between 6 – 7 am, before feeding the goats to avoid the effect of feeds and water on animal's size and conformation (6). A tape measure was used to obtain various body measurements. Aside from the terminologies described and suggested by FAO in characterizing goats, the terminologies used by the local goat raisers to describe specific traits of their goats and as described by Bondoc were also noted (1,6).

Data on the phenotypic characteristics were collected separately among the bucks and does. Pictures were captured for further description and documentation and to have justifications on various phenotypic traits (coat color, horn and ear type, dentition, body measurements, etc.).

Morphological characteristics and morphometric measurements of the goats were based on the FAO Animal Production and Health Guidelines: Phenotypic Characterization of Animal Genetic Resources (6). Morphological or qualitative characteristics include goat characteristics covering only coat color (solid or mixed color), and head profile which includes nose bridge width, ear length, ear type (erect, droopy and long droopy) and horn type (horned, polled and dehorned). On the other hand, the quantitative measurements that were considered include the body length, heart girth, wither height, tail length and testicle circumferences.

Coat color and color markings. Coat characteristics include only the coat color either having solid or mixed coat color. Photographs were taken for further description and documentation.

Head and face profile. Head and face profile include nose bridge width, ear length, ear type (erect, droopy and long droopy) and horn type (horned and polled).

Nose bridge width. Measured as the bridge (end to end) of the nose in the middle part, in centimeter.

Ear length. Distance from the point of attachment to the tip of the ear, in centimeter.

Ear type. Can be categorized into erect, droopy and long droopy based on length (6)

Horn type. Can be categorized into horned which include the dehorned animals, and naturally polled (6)

Body measurements. Different body measurements were obtained when animals are in pens or barns but not when the animals are nervous to prevent stress in the part of the animals that may affect their performance (6). Data were also obtained early in the morning between 6 – 7 am, before feeding the goats to avoid the effect of feeds and water on animal's size and conformation (6). A tape measure was used to obtain various body measurements (cm). Aside from the terminologies described and suggested by FAO in characterizing goats, the terminologies used by the local goat raisers to describe specific traits of their goats and as described by Bondoc was also taken into consideration (6).

The quantitative measurements, including body length, heart girth, wither height, tail length and testicle circumferences were obtained as follows:

***Body length*.** Is measured through the curve of the back from the poll, which is the midway from between the ears up to the base of the tail, in centimeter (6, 16).

Heart girth. Is the circumference of the animal's chest just behind the elbow, in centimeter (6, 16).

Wither height. Is taken through the curve of the back from the front of the hip down to the hoof of the animal, in centimeter (6, 16).

***Testicle circumference*.** Is the circumference of the animal's testicles, in centimeter (6, 16).

Tail length. Measured from the base of the tail to the end of the coccygeal vertebrae, in centimeter (6, 16).

2.2 Statistical Analysis

All data on phenotypic characteristics gathered were consolidated, organized, encoded and tabulated and analyzed using descriptive analysis in terms of frequency counts, percentage distributions and averages (means) using PROC FREQ and PROC MEANS of the SAS System. In addition, analysis of variance was used for numerical traits and was further analyzed using Scheffe's Test.

2.3 Ethics Statement

This study has managed reasonable efforts that minimize the stress and discomfort of animal and all methods during handling and gathering of data related to phenotypic characterization that was permitted by the Ethics Committee on the Animal Welfare Act (RA 8485 as amended by RA 10631).

3 Result and Discussion

In general, based on record and dentition that was done on the different breeds of goats within Oriental Mindoro, and because of the limitations given by the goat raisers only breeder bucks and does (i.e. 1 pair – 2 pairs of teeth which is equivalent to 1.5 to 2.5 years of age) were allowed to phenotypically observed and measured.

3.1 Body Measurements

In general, findings revealed that regardless of sex, Saanen have significantly (p<0.01) longer body length and higher wither height compared to other breeds (Appendix Tables 1 – 6). Likewise, Saanen goats had significantly (p<0.01) higher heart girth over the other goat genotypes but are comparable (p>0.05) with the heart girth of Boer goats. However, Philippine native goats had the least body measurements and were significantly lower (p<0.01) from the rest of the gene pool (Table 2).

It is also prominent that the body measurements of Upgraded have significantly (p<0.01) longer BL than Boer but comparable (p>0.05) to BL of Anglo-Nubian, comparable WH and HG with that of Boer and native goats, respectively. Results can be attributed to the combination of the desirable characteristics of BOR for higher growth rate while NUB was known for its milk production and longer body conformation (5,10).

These results were similar to the range values reported by Mwacharo *et al.,* and Bondoc *et al.,* in the National Goat Registry in the Philippines, the National (Philippines) Goat Breeders' Catalogue, and in the "Animal breeding: Principles and Practice in the Philippine Context". Based on the actual visitation in the various goat farms, the production and management system of the goat raisers are almost similar in terms of feeding, breeding, and overall production management systems (1-4, 10). However, though same production system was employed by the focal farms, differences in the values can also be attributed to the varied vegetation with different crude protein contents (i.e. forage and pasture area), breeding management and selection procedure (7, 9, 15).

Table 2: Body Measurements of goats, regardless of sex, by breed, Oriental Mindoro, Philippines

BREED	BODY MEASUREMENTS (cm)		
	Body length	Wither height	Heart girth
Boer (n=23)	55.615^{c}	53.538^{c}	75.435^{a}
Anglo nubian (n=23)	61.571^{b}	61.478^{b}	70.321^{b}
Upgraded (n=28)	60.783^{b}	54.750^{c}	61.913^{c}
Native (n=28)	50.739^{d}	47.609^{d}	60.885^{c}
Saanen (n=16)	69.000^{a}	65.063^{a}	78.375^{a}

Legend: *Means within column with different superscripts are significantly different (p<0.05)*

Table 3: Body Measurements of goats, regardless of breed, by sex, Oriental Mindoro, Philippines

SEX	BODY MEASUREMENTS (cm)		
	Body length	Wither height	Heart girth
Male (n=49)	59.716^{a}	55.821^{a}	69.448^{a}
Female (n=69)	57.918^{a}	55.816^{a}	67.592^{a}

Legend: *Means within rows with similar superscripts are significantly different (p<0.05)*

In addition, results showed that the body length (BL) of the buck was found to be numerically higher than that of the doe (Table 3). Similar trend was noted on wither height (WH) and heart girth (HG). These differences could be due to sex dimorphisms where buck is phenotypically bigger than does at the same physiological age and stage (9,10).

3.2 Testicle Circumference

Differences in testicle circumference (TC) were observed and measured in bucks available in the farm considering the variations within gene pool (Table 4; Appendix Table 6). Findings revealed that breeds of Saanen, Anglo-Nubian, and Boer goats had significantly higher (p<0.01) TC than the rest of the gene pools with 20.33, 20.30, and 19.67 cm, respectively, compared to the TC of upgraded and Philippine native goats.

Results can be associated to the findings reported by several researchers (3,5) who mentioned that differences in size of testicle could be attributed to genetics and environmental factors such as nutrition, age and weather condition, and the interaction of genotype and environment. Furthermore, TC is a good indication of reproduction rate since it is highly correlated to sperm production, thus the higher the sperm production the higher is the probability of fertilization and reproductive efficiency.

Table 4: Testicle circumference of bucks, by breed, Oriental Mindoro, Philippines

BREED	TESTICLE CIRCUMFERENCE
Boer (n=11)	19.667[a]
Anglo nubian (n=10)	20.300[a]
Upgraded (n=12)	18.500[b]
Native (n=10)	17.271[b]
Saanen (n=6)	20.333[a]

Legend: *Means in column with different superscripts are significantly different (p<0.05)*

3.3 Tail Length

Analysis revealed significant differences in tail length (TL) that were measured and observed among gene pool (Table 5; Appendix Tables 7 and 8). Results showed that breeds of Anglo-Nubian and Saanen were significantly higher (p<0.01) than the rest of the gene pool with TL of 15.435 and 14.438 cm, respectively. However, results showed that TL among goat gene pools are comparable (p>0.05) regardless of sex (Table 6).

Table 5: Tail length of goats, regardless of sex, by breed, Oriental Mindoro, Philippines

BREED	TAIL LENGTH (cm)
Boer (n=23)	12.357[b]
Anglo nubian (n=23)	15.435[a]
Upgraded (n=28)	11.192[bc]
Native (n=28)	10.783[c]
Saanen (n=16)	14.438[a]

Legend: *Means in column with different superscripts are significantly different (p<0.05)*

Table 6: Tail length of goats, regardless of breed, by sex, Oriental Mindoro, Philippines

SEX	TAIL LENGTH (cm)
Male (n=49)	12.552[a]
Female (n=69)	12.857[a]

Legend: *Means in column with similar superscripts are not significantly different(p>0.05)*

There is limited publication and earlier report on phenotypic characterization involving the measurements of TL in goats and its principles, hence this study was conducted. Results can be associated to the findings reported by several researchers (3, 5, 16) who mentioned that differences in TL could be attributed to genetics and environmental factors such as nutrition, age, and weather and health condition. In addition, the TL results were higher than the findings reported by Yakubu *et al*., in West African Dwarf and Red Sokoto goats with a TL of 11.22 cm and 10.34 cm respectively (16).

3.4 Coat Color and Color Markings

In general, Boer, Anglo Nubian, Upgraded and Philippine Native goats have predominantly mixed color while all Saanen goats have solid coat color (Table 7).

All Boer goats characterized in this study have mixed coat color and are all brown head to shoulder and white body. Likewise, Anglo-Nubian goats have predominantly mixed color consisting of black backline with brown to reddish brown body that ranges from 50.00% (bucks) to 61.54% (does), brown-white (10.00%), and brown-black-white (38.46– 40.00%). Moreover, upgraded goats have predominantly mixed color which is generally a combination of brown-black that ranges from 43.75% in does and 75.00% in bucks. In general, these results confirmed the findings of Bondoc *et al*., (1-4) that Anglo-Nubian, Boer and Upgraded gene pool indeed exists in mixture of various colors but differ in color marking distributions.

The Philippine Native goats exist in a variety of colors and were mainly black-brown and some have mixed color of brown, black, reddish brown and have a solid color of white (11.11–20.00%). These results confirmed the findings of Bondoc *et al.*, (1-4) that NA gene pool indeed exist in variety of coat colors.

Findings can be associated with differences in country of origins of the purebred NUB and BOR used in mating both in buck and doe. NUB goats (13) may either be brown-black that were originated from South Africa or NUB goats with pure black or pure brown or mixture of brown-black-white color that were originated from the United States of America. While, BOR goats (13) may either be white-brown or white-light brown that were originated from South Africa or white-black BOR that were originated from Australia and United States of America.

On the other hand, all Saanen goats have solid (creamy white or white) coat color which is similar with the coat color of purebred Saanen (13) that was originated in Australia, United States of America and in South Africa. Available publication or earlier report in the phenotypic characterization of Saanen is very limited because of the sensitivity of the "queen of dairy goat" that may affect its milk production, hence this study was conducted.

3.5 Head and Face Profile

Nose bridge width and ear length. Findings revealed that the nose bridge width (NBW) and ear length (EL) of Anglo-Nubian goats were significantly (p<0.01) moredense and longer with 14.391 and 19.870 cm, respectively (Table 8; Appendix Tables 9 - 12). Likewise, the EL of bucks were significantly longer (p<0.01) than the EL of does (Table 9). On the other hand, analysis revealed that regardless of breed, the NBW of goats are comparable (p>0.05) among bucks and does.

Analysis revealed that EL was higher than the findings reported values by Yakubu *et al*., in West African Dwarf and Red Sokoto goats with an EL of 10.85 cm and 14.52 cm., respectively. Moreover, Pieters mentioned that differences

in the width of nose and length of the ears could be attributed both from genetic (heritable) and environmental factors such as plane of nutrition, age and weather condition (13,16).

Table 7: Coat color of goats, by sex, by breed, Oriental Mindoro, Philippines

SEX	BREED	COAT COLOR (%)			
		BW	BB	BBW	W
MALE	Boer (n=11)	100.00	0.00	0.00	0.00
	Anglo nubian (n=10)	10.00	50.0	40.0	0.00
	Upgraded (n=12)	25.00	75.0	0.00	0.00
	Native (n=10)	30.00	50.0	0.00	20.0
	Saanen (n=6)	0.00	0.00	0.00	100.0
FEMALE	Boer (n=12)	100.00	0.00	0.00	0.000
	Anglo nubian (n=13)	0.00	61.5	38.4	0.00
	Upgraded (n=16)	43.75	43.7	12.5	0.00
	Native (n=18)	38.88	44.4	5.55	11.11
	Saanen (n=10)	0.00	0.00	0.00	100.00

Legend: *BW – brown white; BB – brown black; BBW – brown black white; W - white*

Table 8: Nose bridge width and ear length of goats, regardless of sex, by breed, Oriental Mindoro, Philippines

BREED	NOSE BRIDGE WIDTH (cm)	EAR LENGTH (cm)
Boer (n=23)	10.478^{c}	17.957^{b}
Anglo nubian (n=23)	14.391^{a}	19.870^{a}
Upgraded (n=28)	12.036^{b}	16.643^{c}
Native (n=28)	8.846^{d}	11.269^{e}
Saanen (n=16)	10.875^{bc}	13.687^{d}

Legend: *Means in column with different superscripts are significantly different (p<0.05)*

Table 9: Nose bridge width and ear length of goats, regardless of breed, by sex, Oriental Mindoro, Philippines

SEX	NOSE BRIDGE WIDTH (cm)	EAR LENGTH (cm)
Male (n=49)	11.030^{a}	16.898^{a}
Female (n=69)	11.714^{a}	15.298^{b}

Legend: *Means in column with different superscripts are significantly different (p<0.05)*

Horn type. More than half (66.67 – 70%) of the Anglo-Nubian, Upgraded and Philipine Native buck have horn while all Boer and Saanen goats are horned. On the other hand, majority of the does are dehorned (Table 10). These results can be associated to the management practices of the goat raisers that bucks are not usually dehorned to maintained their aggressiveness, libido and masculinity. Furthermore, presence of horn in male animals is a good indication of higher reproductive efficiency since it is considered a factor in successful mating due to detection of does that are in estrus period, thus the higher probability of conception (7,9).

Ear type. Results showed that regardless of sex, majority of the Boer and Upgraded goats have droopy ears while more than half (53-60%) of the Anglo-Nubian goats have long droopy ears. On the other hand, findings revealed that all Saanen and Philippine native goats have erect ears. These results can be associated to the conclusions of Pieters and Yakubu *et al*., who mentioned that differences in the ear type can be directly correlated to ear length that could be attributed both from genetic (heritable) and environmental factors such as plane of nutrition, age and weather condition (13,16).

Table 10: Horn and ear type of goats, by sex, by breed, Oriental Mindoro, Philippines

SEX	BREED	HORN TYPE (%)		EAR TYPE (%)		
		H	DE	LD	DR	ERECT
MALE	**Boer (n=11)**	100	0.0	0.0	100	0.0
	Anglo nubian (n=10)	70.0	30.0	60	40	0.0
	Upgraded (n=12)	66.6	33.3	0.0	100	0.0
	Native (n=10)	70.0	30.0	0.0	0.0	100
	Saanen (n=6)	100	0.00	0.0	0.0	100
FEMALE	**Boer (n=12)**	36.3	63.6	16.6	83.3	0.0
	Anglo nubian (n=13)	15.3	84.6	53.8	46.1	0.0
	Upgraded (n=16)	37.5	62.5	0.0	100	0.0
	Native (n=18)	16.6	83.3	0.0	0.0	100
	Saanen (n=10)	0.00	100	0.0	0.0	100

Legend: *H – horned; DE – dehorned; LD – long droopy; DR - droopy*

4 Conclusion

The findings of the study led to the following conclusion:

1. Findings revealed variations in the phenotypic characteristics of goat gene pool. Generally, regardless of

sex, Saanen goats have significantly longer body length and higher wither height compared to other breeds. Likewise, they had significantly higher heart girth over the other goat genotypes but are comparable with the heart girth of Boer goats. However, Philippine native goats had the least body measurements and were significantly lower from the rest of the gene pool. In addition, results showed that the body length of the buck was found numerically higher than that of the doe. Similar trend was noted on wither height and heart girth.

2. The breeds of Saanen, Anglo-Nubian, and Boer goats had significantly higher testicle circumference than the rest of the goat in the gene pools.

3. Anglo-Nubian and Saanen have significantly longer tail length than the rest of the gene pool. However, results showed that tail length among goat gene pools are comparable regardless of sex.

4. Boer, Anglo Nubian, Upgraded and Philippine Native goats have predominantly mixed color while all Saanen goats have solid coat color.

5. The nose bridge width and ear length of Anglo-Nubian goats were significantly (p<0.01) denser and longer. Likewise, the ear lengths of bucks were significantly longer than that of the does. On the other hand, analysis revealed that regardless of breed, the nose bridge width of goats is comparable among bucks and does.

6. More than half of the Anglo-Nubian, Upgraded and Philippine Native buck have horn while all Boer and Saanen goats are horned. On the other hand, majority of the does are dehorned. Results showed that regardless of sex, majority of the Boer and Upgraded goats have droopy ears while more than half of the Anglo-Nubian goats have long droopy ears. On the other hand, findings revealed that all Saanen and Philippine native goats have erect ears.

7. For future goat breeding program, results suggest to include or cross Saanen, Anglo-Nubian and Boer to other goat breed groups to improve the growth performance of goat. In addition, goat enthusiasts, geneticist and breeder may include Anglo-Nubian in their breeding and selection program if they want to have long droopy ears and denser nose (nose bridge width). Likewise, Anglo-Nubian and Saanen goats can be included in improving reproductive efficiency (i.e. testicle circumference).

5 Recommendation

Based on the results of the study, it is recommended to utilize Saanen, Anglo-Nubian, and Boer as breeders, if the goals of the goat raisers and enthusiasts are to improve the growth rate based on their longer body length, and higher heart girth and wither height that serve as pre-requisites in weight estimation in the absence of expensive weighing scale. In addition, improvement of nose bridge width and ear length can be done by including Anglo-Nubian goats in the breeding program while improvement of reproductive traits based on testicle circumference using Saanen and Anglo-Nubian goats are recommended since these influence the semen production and health condition. Moreover, it is also recommended that an investigation on the genetic characterization of various goat gene pools using microsatellite markers will be done to complement the results obtained from phenotypic characterization.

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